Research Article

The Effect of Far-Infrared Radiation on Waist Skin Surface Temperature, Meridian Resistance and Heart Rate Variability in Healthy Adults: A Quasi-Experimental Study

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ABSTRACT

Background: In recent years Far-Infrared Radiation (FIR) meters are commonly used in home health care. In Traditional Chinese medicine, acupuncture is administered before far infrared radiation is applied to the patient. This study investigates the effects of FIR on the Waist Skin Surface Temperature (WSST), meridian resistance, and Autonomic Nervous System (ANS) activity to evaluate its effectiveness in reducing discomfort.

Methods: A single group pre and post test study was designed. Subjects (n=30) over 20 years of age and satisfying the inclusion criteria were selected. Subjects received 40 minutes far-infrared radiation on their backs. The WSST, meridian resistance, autonomic nervous activity, and blood pressure were assessed.

Results: The results showed skin surface temperature at the waist increased from 34.33 ± 0.19°C to 39.03 ± 0.11°C. FIR caused a significant increase of the WSST after 40 minutes irradiation (P=.001). The ANS low-Frequency (LF) activity showed a statistically significant decrease (P=.001) and the LF/HF ratio showed a statistically significant increase (P=.002). Diastolic Blood Pressure (DBP) increased significantly (P=.01), and Heart Rate (HR) showed a statistically significant decrease (P=.001). Meridian resistance at the lung meridian, pericardial meridian, heart meridian, small intestine meridian, large intestine meridian, sanjiao meridian, and Gallbladder meridian showed a statistically significant decrease (P<.05).

Conclusion: FIR significantly increased the WSST after 40 minutes irradiation, which showed an increase in diastolic blood pressure and heart rate. Meridian resistance was reduced suggesting regulation of ANS activity.

ABBREVIATIONS

FIR: Far-Infrared Irradiation, WSST: Waist Skin Surface Temperature, ANS: Autonomic Nerve System, HRV: Heart Rate Variability, HR: Heart Rate, HF: High Frequency, LBT: Left Big Toe, LFD: Left Foot Dorsal, LF: Low Frequency, LHR: LF/HF Ratio, SST: Skin Surface Temperature.

INTRODUCTION

Background

Since 1990, Lower Back Pain (LBP) has been one of the leading causes of disability and remains a significant global public health concern. The discomfort of the waist often due to lower back pain. Global Burden of Disease studies have defined LBP as

"pain in the area on the posterior aspect of the body from the lower margin of the twelfth rib to the lower gluteal folds with or without pain referred into one or both lower limbs that lasts for at least one day. In 2017, it was estimated that 7.5% of the global population, approximately 577 million people suffered from LBP [1]. Systematic literature reviews examining the prevalence of LBP on a yearly basis found specific occupational categories to be more prominent: LBP was found to range from 48.6%-73.8% among physicians. Nurses ranged from 63.8%-74.8%, while dentists, ranged from 57.4%-92.6%. Risk factors for LBP among Individuals included age (26-64years) [2,3], history of back trauma, obesity, smoking, marital status [2], psychological distress, work 41 to 45 hours per week, female [4], and osteoporosis [5].

Far-Infrared Radiation (FIR) is a low-energy therapy, where the Infrared Radiation (IR) is an invisible electromagnetic wave with a defined wavelength region of 0.75-1000μm on the light spectrum. N near-infrared is between 0.75-1.5μm, mid-infrared is between 1.5-4.0μm, far-infrared is between 4.0-1000μm, and the wavelength band of 4.0-14μmhas been shown to have an effective absorption and is used by living organisms [6]. FIR has the potential to reduce oxidative stress, accelerate tissue proliferation and act in an anti-inflammatory capacity. FIR can be used in a clinical setting to suppress pain due to surgery or disease. FIR has been shown to have a modulating effect on cytokines which act to reduce inflammation and promote blood vessel dilation [7]. FIR is an invisible, non-ionizing radiation of electromagnetic wave and widely used in medicine, as the thermal and non thermal effects have shown many positive benefits effects in both human and animal studies. The thermal component of radiation heat transfer is measured in W/m2 (q) from a body to its surroundings and is proportional to the fourth power of the absolute temperature. This value is calculated as: $q = \varepsilon\sigma T4$. Where σ is a fundamental physical constant called the Stefan–Boltzmann constant. The emissivity, ε, of the surface of a material is its effectiveness in emitting energy as thermal radiation and varies between 0.0 and 1.0. Another important radiation property of a surface is its absorptivity, α, which is the fraction of the radiation energy incident on a surface that is absorbed by the surface. As with emissivity, the value of absorptivity is in the range $0 < \alpha < 1$. The Stefan–Boltzmann law gives the radiant intensity of a single object, however using the Stefan–Boltzmann law, the radiation heat transfer between two objects can be quantified. Two bodies radiating toward each other share a net heat flux. The net flow rate of heat between them is given by: $Q = \varepsilon\sigma A1\text{-}2\ (T41 - T42)$ [J/s] and $q = \varepsilon\sigma\ (T41 - T42)$ [J/m2s]. However, due to the area factor A1-2, which is the area viewed by body 2 of body 1, it becomes fairly difficult to calculate. As the human body generates heat and the area irradiated by FIR covers a non planar surface, quantifying absorption of FIR is beyond the scope of the current study.FIR has been shown to positively effect: (1) pain control [6,8,9], (2) emotional disorders [10], (3) muscle damage post exercise [7], (4) lymphedema [11], (5) psychotoxicdisorders [12], (6) and Dysmenorrhea [13].

The ANS is important for maintaining the internal homeostasis of the human body. The ANS is comprised of two components, 1) sympathetic and 2) parasympathetic. The ANS supplies the internal organs, including the blood vessels, stomach, intestine, liver, kidneys, bladder, genitals, lungs, pupils, heart, and sweat, salivary, and digestive glands. The parasympathetic and sympathetic systems act to modulate responses without conscious effort. Heart Rate Variability (HRV) analysis has been widely used in research, to evaluate the activity of the ANS [14]. Studies have found that HRV is associated with many conditions, such as pain [15], cardiovascular disease, metabolic syndrome, severe arteriosclerosis, dyslipidemia, obesity, and hypertension [16].

Traditional Chinese Medicine (TCM) uses the meridian system to diagnose many diseases [17] as well as assess and treat pain [18,19]. In TCM the Twelve Major or Primary Meridians are considered the most important meridians of the body. They connect to the Zang-fu organs and are the main pathways that transport qi and blood throughout the body. Each meridian has sub channels for qi and blood flow. The meridian system breaks down further into collaterals, and sub-collaterals. The term meridian is the internationally agreed upon descriptor of Chinese medicine energy channels. There are 14 meridian channels (main channels) distributed longitudinally on the human body through which qi and blood circulate. Qi and blood are considered the essential substance and energy of the body. Qi flows in the channels and spreads throughout all organs and

tissues and may not be absent anywhere [20]. Meridians are also found to be lower-resistance passages for cell migration in the extracellular matrix where, mast cells may migrate longitudinally along meridians [21].

Objectives

This study investigates the effects of Far Infrared Irradiation (FIR) on the Waist Skin Surface Temperature (WSST), meridian resistance, and Autonomic Nervous System (ANS) activity to evaluate its effectiveness in reducing waist discomfort.

METHODS

Trial design and setting

A quasi-experimental study, single-group pretest-post-test design was performed. Changes in skin surface temperature, ANS activity, BP, and meridian electrical groups were examined before and after the intervention (Figure 1). In an independent laboratory, the indoor ambient temperature was controlled at 22°C-24°C, and the humidity controlled at 60-70%.

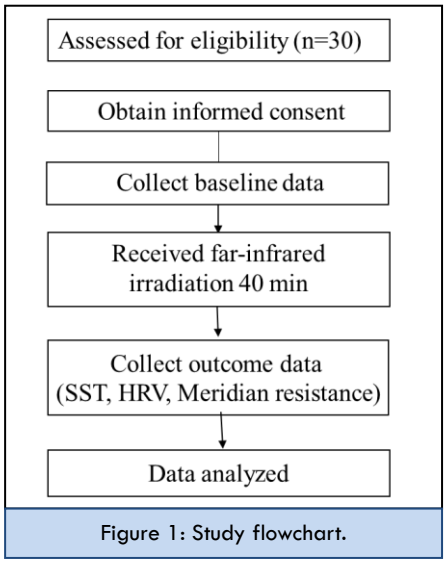

Figure 1: Study flowchart.

Participants

Adult volunteers over 20 years of age were selected for this study. Selection criteria was as follows: (1) 20 years of age or older, (2) no chronic disease, (3) not on medication. Exclusion criteria: (1) wounds or skin lesions on the back or waist, (2) musculoskeletal or neuropathy of the back or waist, 3) fever, (4) pregnancy.

The sample size was estimated with an α value of 0.05, power 0.8, and effect size 0.5. According to G-power 3.1 estimation, the sample size required was 27. The estimated sample loss rate is 10%, so the sample size required 30 participants.

Intervention

In this study, FIR was used to irradiate the waist vertically, and the acupoints included Yaoyangguan (DU3), Dachangshu (BL25), Mingmen (DU04), Shenshu (BL23) and Zhishi (BL52). The FIR model employed was OIR-361 Ogimi (No. 002953 issued by the Taiwan Ministry of Health and Welfare), which uses a ceramic heating plate to reflect 3-15um wavelength infrared rays. The irradiation distance was 20 cm, irradiation time was 40 minutes [22], and the temperature was controlled at 39-43 °C (Figure 2). Prior to FIR, the participants sat and rested for 20 minutes. Participants were placed in a prone position with the waist exposed. The pre-test data collected included: waist temperature, blood pressure, heartbeat, and meridian resistance. During the irradiation process, the waist temperature, heartbeat and heart rate variability of the subjects were continuously monitored. At the end of FIR, the subjects remained lying down and rested for 20 minutes. The post-intervention data collected included Waist Surface Skin Temperature (WSST), Blood Pressure (BP), heartbeat, Heart Rate Variability (HRV), and Meridian Resistance (MR).

Figure 2: FIR on the waist.

Outcomes measurement

Participants' demographic data included: age, gender, past medical history, smoking, alcohol and coffee consumption. The skin surface temperature was measured using American BIOPAC Systems, Inc., (model MP-36 (Ministry of Health, Medical Instrument No. 021684). Both heart rate variability and heart rate can be monitored at the same time. The sphygmomanometer (manufactured by Focal factory, Japan, model FC-110) has a measurement range of 20-280mmHg ±

4mmHg. The meridian resistance was measured using a Meridian Energy Analysis Devices (MEADs) [23] (No. 002062, manufactured by the Department of Health, Medical Instruments) to assess the twelve meridian acupoints. The data is displayed as 0~100 units, which yielded electrodermal measurements of the 12 Ryodoraku meridian points. These meridian points included: lung (LU9), pericardium (PC7), heart (HT7), small intestine (SI4),triple energizer (SJ4), Large Intestine (LI5), spleen (SP3), liver (LR3), kidney (KI4), bladder (BL65), gallbladder (GB40), and stomach (ST42) [24].

Ethical considerations

Prior to the study, the research plan, purpose, process and method was explained to the participants. During the research, the participants retained the right to ask any questions related to the study. Informed consent was obtained from the participants, and the right to withdraw from the research project at any time was made known. This study was approved by the Human Trials Board (IRB101-56).

Statistical methods

The research data was analyzed using SPSS 19.0 for Windows statistical software. Descriptive statistics analyzed the categorical variables of the participants' basic data including percentage, mean, and standard deviation. Inferential statistics used independent sample T test to analyze whether there were differences in skin surface temperature, blood pressure, autonomic nerve activity, and meridian resistance before and after FIR intervention.

RESULTS

A total of 30 participants, 28 females (93.3%) and 2 males (6.7%), aged 22.9 ± 3.56, ranging from 21 to 39 years old were studied. None of the participants were smokers, 20% drank coffee every day, 36.7% used the computer for 4-5 hours, 40% used the computer for more than 6 hours, and 50% experienced back pain (Table 1).

Table 1: Groups demographic characteristics (n=30).

Variables	Participants	Percentage (%)
Gende		
Male	2	93.3
Female	28	6.7
Age (mean ±SEM)	22.9 ± 3.56	
Low back pain		
Yes	15	50
No	15	0

Changes in WSST (Waist Skin Surface Temperature)

The WSST of the waist acupoints under FIR increased from 34.33±0.19°C to 39.03±0.11°C, with a peak at 39.23±0.12°C at the 30th minute. There were statistically significant differences (P=.001) in the changes of SST irradiated by FIR at different time points (Table 2, Figure 3). The temperature was maintained until the end of the FIR session. The subjects (90%) indicated that the FIR had a relaxed and comfortable sensation at the waist.

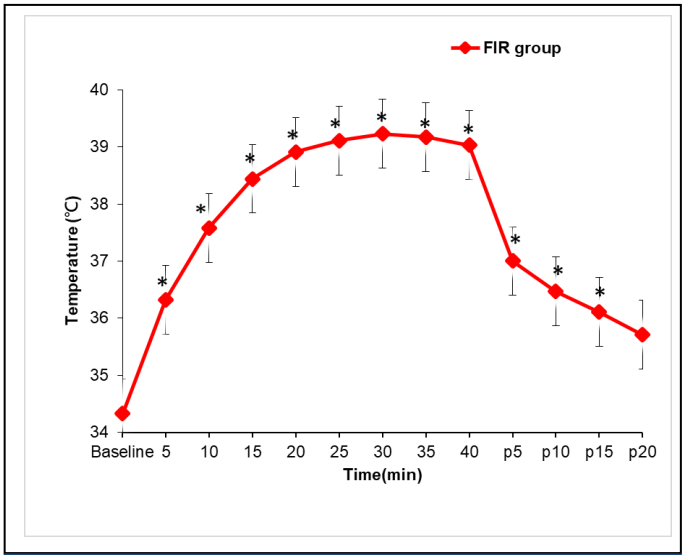

Figure 3: Change in skin surface temperature on the waist.

HRV (LF, HF, LF/HF ratio) changes

The LF value at each stage was compared with the pre- test data over the duration of the FIR intervention. Statistically significant differences were found at 10 minutes (z=-2.2, P=.014), 15 minutes (z=-3.15, P=.001), 20 minutes (z=-3.03, P=.001), and 35 minutes (z=-3.77, P=.001). Studies have shown that FIR can reduce the activity of low-frequency sympathetic nervous activity associated with HRV.

The HF value at each stage when FIR waist acupoints were irradiated showed a slight increase compared with the pretest data. However, no significant difference was found, indicating that FIR did not alter the parasympathetic nervous activity. In terms of LF/HF ratio (LHR), LHR was significantly different at 30 minutes (z=-2.89, P=.002), 35 minutes (z=-2.78, P=.003), and 40 minutes (z=-2.82, P=.002). The LF/HF ratio can be used as an indicator of the balance of sympathetic and parasympathetic nervous activity, and FIR shows a statistically significant effect on HRV after 30 minutes (Table 3).

Table 2: WSST at different time points from baseline. Friedman test was used to compare the within group difference. *: P<.05.

Measurement indices	Baseline	5 min	10min	15 min	20 min	25 min	30 min	35 min	40 min	P 5 min	P 10min	P 15 min	P 20 min
	Mean(SD) ℃												
FIR	34.33(0.19)	36.32(0.11)	37.58(0.12)	38.44(0.13)	38.91(0.14)	39.11(0.13)	39.23(0.12)	39.17(0.12)	39.03(0.11)	37.00(0.14)	36.47(0.17)	36.11(0.18)	35.71(0.20)
Difference	-	2.00	3.3.0	4.10	4.60	4.80	4.90	4.90	4.70	2.70	2.2	1.80	1.38
Z	-	-4.782*	-4.782*	-4.782*	-4.782*	-4.783*	-4.782*	-4.783*	-4.783*	-4.782*	-4.681*	-4.515*	-4.514

Table 3: Changes in HRV, BP, HR Pre and Post FIR therapy. T test was used to compare the difference within group from baseline. *p<.05.

Measurement indices	Baseline	30 min	35 min	40 min
	Mean(SD)			
LF	47573(20053)	46870(19756)	44148(18609)	45666(19249)
Difference	-	-703	-3425	-1907
Z	-	-.366	-3.774*	-1.867
HF	54961(16188)	52498(15462)	57411(16909)	55107(16231)
Difference	-	-2463	2450	146
Z	-	-.979	.943	.061
LF/HF ration	.866(1.24)	1.056(1.51)	1.046(1.49)	1.046(1.49)
Difference	-	.19	.18	.18
Z	-	2.890*	2.797*	2.820*
SBP	106(9.5)	-	-	106.8(11)
Difference	-	-	-	.8
Z	-	-	-	.734
DBP	66(9.6)	-	-	69.7(10.1)
Difference	-	-	-	3.7
Z	-	-	-	2.303*
HR	75.0(3.2)	73.0(2.3)	-	72.6(2.1)
Difference	-	-2.0	-	-2.6
Z	-	-4.057*	-	4.293*

Table 4: Changes in the meridian resistance before and after FIR intervention. *p<.05. Unit: uA.

Measurement indices	**Left**	**Right**	**Measurement indices**	**Left**	**Right**
	Mean(SD)			**Mean(SD)**	
Lung Meridian			Spleen meridian		
pre test	35.5(26.3)	33.9(26.7)	pre test	35.4(18.9)	37.3(19.6)
post test	24.9(19.3)	24.9(19.3)	post test	33.3(21.9)	34.1(21.5)
Z	-2.581*	-3.054*	Z	-0.946	-0.514
Pericardial meridian			Liver meridian		
pre test	34.4(25.6)	31.4(24.2)	pre test	25.3(16.7)	27.7(20.7)
post test	23.6(19.0)	25.3(19.8)	post test	29.3(22.2)	23.9(19.3)
Z	-2.335*	-1.985*	Z	-1.553	-0.761
Heart meridian			Kidney meridian		
pre test	29.2(22.8)	23.7(21.7)	pre test	20.1(19.4)	17.5(17.2)
post test	22.3(16.7)	18.9(18.9)	post test	16.5(19.5)	14.7(14.7)
Z	-2.081	-2.571*	Z	-1.635	-1.409
Small intestine meridian			Bladder meridian		
pre test	32.4(28.1)	28.5(25.0)	pre test	38.2(19.0)	33.5(16.3)
post test	24.3(20.2)	21.0(20.7)	post test	35.4(23.1)	32.6(19.8)
Z	-1.189	-2.787*	Z	-0.617	-0.175

Large intestine meridian			Gallbladder meridian		
pre test	39.3(27.1)	41.6(23.7)	pre test	12.3(131.9)	14.4(13.6)
post test	30.1(21.3)	32.1(22.5)	post test	9.1(10.4)	13.9(14.5)
Z	-1.934	-3.630*	Z	-2.356*	-0.154
Sanjiao meridian			stomach meridian		
pre test	34.7(24.8)	31.8(22.7)	pre test	18.3(14.7)	20.2(17.2)
post test	26.4(18.8)	23.2(14.9)	post test	18.3(16.5)	17.5(15.7)
Z	-2.407*	-2.314*	Z	-0.401	-1.553

BP and HR changes

BP changed under FIR at waist acupoints, and showed systolic blood pressure increased from 106 ± 9.5mmHg to 106.8 ±11mmHg. The diastolic blood pressure increased from 66 ± 9.6mmHg to 69.7 ± 10.1mmHg, and was statistically significant (P=.01). The change in HR showed a decrease from 75.0 ± 3.2 to 72.6±2.1 beats/min, which was significantly different (P=.001).The within group changes in HR at different time points were also statistically significant. (P=.001) (Table 3).

Meridian change

Before and after FIR, the Meridian Resistance (MR) was measured. The left lung meridian decreased from 33.9 ± 26.7 to 24.9 ±19.3 (P=.005). Right lung meridian decreased from 34.4 ± 25.6 to 24.9 ± 19.3 (P=.001). The left pericardium meridian decreased from 34.4 ± 25.6 to 23.6 ± 19.0 (P=.006). The right pericardium meridian decreased from 31.4 ± 24.2 to 25.3 ± 19.8 (P=.024). The left heart meridian decreased from 29.2 ± 22.8 to 22.3 ± 16.7. The right heart meridian decreased from 23.7 ± 21.7 to 18.9 ± 18.9 (P=.012). In the pre-test and post-test results of FIR, except for the left heart meridian, there was no statistically significant difference.

The meridians decreased from 32.1 ± 28.1 to 24.3 ± 20.2 in the left small intestine meridian, and decreased from 28.5 ± 25.0 to 21.0 ± 20.7 in the right small intestine meridian (P=.003). The left large intestine meridian decreased from 39.3 ± 27.1 to 30.1 ± 21.3. The right large intestine meridian decreased from 41.6 ± 23.7 to 32.1 ± 22.5 (P=.001). Left Sanjiao meridian decreased from 34.7±24.8 to 26.4±18.8 (P=.007). Right Sanjiao meridian decreased from 31.8 ± 22.7 to23.2 ± 14.9(P=.010). In the post-test and pre-test results of FIR, the right small intestine meridian, right large intestine meridian, and Sanjiao meridian all showed a statistically significant difference. In terms of the left spleen meridian decreased from 35.4 ±18.9 to 33.3 ± 21.9. The right spleen meridian decreased from 37.3±19.6 to 34.1±21.5. Left liver meridian decreased from 29.3 ± 22.2 to 25.3 ± 16.7. The right liver meridian decreased from 27.7±20.7 to 23.9±19.3. Left kidney meridian decreased from 20.1 ± 19.4 to 16.5 ± 19.5. The right kidneys meridian decreased from 17.5±17.2 to 14.7±14.7. Although the resistance of the spleen, liver and kidney meridians decreased, there was no statistically significant difference.

For the left bladder meridian decreased from 38.2 ± 19.0 to 35.4 ± 23.1. The right bladder meridian decreased from 33.5 ± 16.3 to 32.6 ± 19.8. The left gallbladder meridian decreased from 12.3 ± 13.9 to 9.1 ± 10.4(P=.001). The right gallbladder meridian decreased from 14.1±13.6 to 13.9±14.5. The left gastric meridian ranged from 18.3 ± 14.7 to 18.3 ± 16.5. The right gastric meridian decreased from 20.0 ± 17.2 to 17.5 ± 15.7. There were statistically significant differences in the left gallbladder meridian (Table 4).

DISCUSSION

Participant demographic analysis

High risk occupations for LBP include (1) secondary and tertiary hospital workers (physicians, dentists, nurses, physical therapists), (2) Prolonged standing at work (3) Severe work stress levels, (4) excessive bending and twisting [2]. Participants in this study showed that 36.7% used the computer for 4-5 hours a day, 40% used the computer for more than 6 hours, 83.3% exercised irregularly, and 50% had LBP.

Changes in Waist Skin Surface Temperature (WSST)

FIR therapy is a low-energy therapy, and requires a period of time before the effect can be measured. This study found that after 25 minutes of continuous irradiation, the WSST will exceed 39°C. The WSST temperature will remain between 39°C and 40°C on average, with a maximum temperature of 40.4°C. A relaxed and comfortable sensation on the lower back was reported by 90.0% of the subjects undergoing FIR.

Previous research has shown that the analgesic effect by FIR can be divided into two categories: the thermal and non-thermal effect. The thermal effects aid in the expansion of blood vessels, acting to improve peripheral circulation [9,25-27], with an apparent cascade effect of pain reduction. Both thermal and non-thermal effects relieve pain via cytokine modulation [8]. FIR treatment was effective for alleviating delayed-onset muscle soreness (DOMS) and enhancing the recovery of proprioception after Eccentric Exercise (EC) [28]. FIR transmits thermal energy and improves vasodilation, while non-thermal effect includes antioxidant and anti-inflammatory potential. It also acts to attenuate monocyte chemoattractant protein-1, TNFα-induced adhesion molecule E-selectin, and vascular cell adhesion protein-1 [12]. The multiple effects of FIR and the specificity of action remain to be entirely quantified.

The Effects on HRV, BP, and HR

This study investigated the effect of FIR on the ANS. The ANS indices including HRV (LF, HF, L/H ratio) where it was found that the LF and HR were significantly decreased at the 35 min time point, while the L/H ratio was significantly increased. The current study showed that FIR stimulation induced significant HRV responses. A decrease in HF and an increase in LF/HF ratio remained statistically significant post FIR irradiation at 15 min (post-effect), although there was no significant change on the LF power. These results suggest an increasing sympathetic/parasympathetic balance during FIR stimulation and increased peripheral blood perfusion [13,29,30]. The effect of FIR on the ANS has been confirmed in other studies, where FIR was shown to decrease HR. The HRV components of HF [31] and LF were significantly increased; indicating increased sympathetic and parasympathetic nerve activity [22]. Further, the BP component of DBP was found to be significantly increased post FIR, while remaining within normal range. By, contrast other research showed no significant difference between SBP or DBP [9,32]. The findings in this study correlate with the research, referenced, and suggest that the reason for the changes in the ANS and HR is related to WSST due to FIR as result of increased blood flow, vasodilation and cytokine cascade.

FIR effects on meridians

An important finding of this study showed that FIR affects all 12 meridians. Meridian resistance was measured pre and post FIR. The overall meridian resistance was 29 ± 16.3 pre-test and 24.1 ± 13.7 post-test and showed a significant decrease ($Z=-2.238$, $P<0.05$). Among the 12 meridians affected, the lung meridian, pericardium meridian, and small intestine meridian showed a reduction, while the large intestine meridian, Sanjiao meridian, and left gallbladder meridian showed a statistically significant reduction. Chen et al. study showed that FIR for 30min can reduce the resistance of the spleen, liver, kidney, and gallbladder meridians [33]. Bioceramics is one of the Far-Infrared (FIR) emitting materials, which has the characteristic of emitting non-ionizing radiation and visible photo-luminescence [34]. Leung, et al study investigated the advantages of Photo Luminescent Bioceramic (PLB) irradiation on the Gallbladder (GB) meridian channel as well as other acupuncture points and showed PLB improved meridian current levels at the GB, lung, small intestine, bladder, and kidney [24]. Similarly, Chen et al, studied PLB irradiation of 15 minutes and found it, influenced the the lung, liver, gall bladder, spleen, Sanjiao, heart, and pericardium meridians [35]. Based on this study and other corroborating research, FIR is shown to be effective at reducing meridian resistance with the concomitant effect of improved mood. This study is unique in that it was the first time that FIR was studied when applied to the waist. The changes in WSST showed that it had a significant impact on autonomic nerves and meridian resistance, which may be used as a reference for future research on low back pain.

Limitations

Due to time, financial and laboratory constraints, this research was limited in scope due to sample size and analysis techniques. To allow for generalization of the results, a much larger sample size is required along with inclusion of those suffering various diseases. The effects of medication on FIR was not assessed and could lead to different outcomes as a result of biochemical effects.

CONCLUSION

Far-infrared irradiation is an effective, safe and readily administered non-invasive therapeutic modality. Far-infrared irradiation of waist acupoints found that FIR can reduce the resistance of the lung, pericardium, heart, small intestine, Sanjiao and large intestine meridians and increase the circulation of Qi. Through balancing the sympathetic and parasympathetic nerves, this suggests that FIR is effective at

reducing the phenomenon of lower back pain resulting in improved mood.

CONFLICTS OF INTEREST

Authors report no potential conflicts of interest to declare.

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AUTHOR CONTRIBUTIONS

Contributors Lee-Mei Chi: conception, design, analysis and interpretation of data, drafting of the manuscript, final approval. Tai-Chu Peng: conception, design, interpretation of data, critical revision of manuscript, final approval. Hui-Chun Chang: analysis and interpretation of data, critical revision of manuscript, final approval. Li-Mei Lin: interpretation of data, critical revision of manuscript, final approval. Conceptualization: TCP. Data curation: HCC, LML. Formal analysis: TCP, HCC, LMC. Investigation: HCC, LML, LMC. Methodology: TCP, LMC. Writing - original draft: LMC. Writing - review & editing: TCP, LMC.

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